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ABSTRACT

The present series of studies was undertaken to explore intersensory processing in the very young. In the first experiment 1-, 4- and 7-month-old infants experienced simultaneously their mothers' faces and voices. The various conditions consisted of displacing the voice from the face. The results indicated that infants as young as one month of age show increased looking behavior although there was no indication of emotional upset when there was face-voice displacement. In order to determine why voice displacement results in increased looking, several other face-voice pairings were observed. In the second experiment face-voice discrepancies, such as mother's face with stranger's voice, were presented. The results indicate that face-voice discrepancy is as effective as face-voice displacement, suggesting the face-voice schema integration exists in the very young. These results are discussed in the context of the integration of schema in the young infant. (Author)

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RESEARCH BULLETIN

NORMAL AND DISCREPANT FACE-VOICE INTEGRATION IN EARLY INFANCY

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and
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Educational Testing Service
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Normal and Discrepant Face-Voice Integration in Early Infancy

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Abstract

The present series of studies was undertaken to explore intersensory processing in the very young. In the first experiment 1-, 4- and 7-month-old infants experienced simultaneously their mothers' faces and voices. The various conditions consisted of displacing the voice from the face. The results indicated that infants as young as one month of age show increased looking behavior although there was no indication of emotional upset when there was face-voice displacement. In order to determine why voice displacement results in increased looking, several other face-voice pairings were observed. In the second experiment face-voice discrepancies, such as mother's face with stranger's voice, were presented. The results indicate that face-voice discrepancy is as effective as face-voice displacement, suggesting that face-voice schema integration exists in the very young. These results are discussed in the context of the integration of schema in the young infant.

Normal and Discrepant Face-Voice Integration in Early Infancy[1]

Michael Lewis, Linda Townes-Rosenwein, and Harry McGurk

Educational Testing Service

Our world simultaneously presents us with an enormous amount of stimulation in many modalities. Despite this fact, the study of perception has primarily focused on the ability to process information one modality at a time, as if this ability could be separated out from responsiveness to the environment as a whole. One of the implicit concepts underlying this kind of work with young children seems to be that the child starts with the ability to process information in one modality at a time and later develops an ability to integrate information from more than one modality (Birch & Lefford, 1967; Piaget, 1952). Recently, however, some researchers (Carpenter, 1973; Goodnow, 1971) have begun to question this assumption.

The present study was undertaken in the belief that the exploration of the origins of intersensory processing is vital to understanding the child's response to and conception of his world. Up until this time, only a few researchers have studied this problem in infancy (Aronson & Rosenbloom, 1971; Birch & Turkewitz, 1966; Korner & Beason, 1972; Piaget, 1952).

We were also interested in discovering what simultaneous presentations of intersensory information, originating from the same source (from the adult's point of view), could add to knowledge about schema development in infancy. Thus, we chose the human being (mother and female stranger) as a multimodal stimulus naturally occurring in the infant's environs. Previous work has clearly indicated that intramodal violations of the normal face "schema" are differentially responded to, at least by infants of three months of age and older (Haff & Bell, 1967; Hershenson, Kessen, & Munsinger, 1967; Kagan, Henker, Hen-Tov, Levine, & Lewis, 1966; Lewis, 1969), but no work besides Aronson and Rosenbloom's (1971) and Bell's (1970) has examined intermodal person schema. Aronson and Rosenbloom's

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(1971) study on the intersensory integrative capacities of very young infants (one month old) is particularly important because they chose to investigate the integration of auditory (human voices) and visual (human faces) information rather than the visual-haptic integration. Aronson and Rosenbloom (1971) found that infants at the incredibly young age of one month were upset by the spatial displacement of the mother's voice while she was talking. In view of the pioneering nature of this work, it was important to have confidence in the findings. Aronson and Rosenbloom (1971) did not control for the order of presentation of normal face-voice and displaced-voice presentations; the infants might have become upset through fatigue or some other temporal variables, since the violation stimuli were always presented at the end of each session. Second, Aronson and Rosembloom chose increased tonguing as a measure of distress. More frequent tonguing during the violation stimuli might have occurred because the infants were hungrier by the end of the experiment. In any case, it has not been empirically demonstrated that the amount of tonguing is in any way related to distress. Third, to simulate the normal face-voice pairing in which the mother's voice came from the same direction in which she was seen by the infant, two loudspeakers were used, one on either side of the infant. To simulate the violation condition in which the voice was displaced from the person talking, they used only one loudspeaker. Thus, the differential responding to violation versus normal stimuli might have reflected a monophonic versus a stereophonic effect and not a displacement from the face-voice effect.

For these reasons, it was decided first to replicate Aronson and Rosenbloom's work using the three new controls indicated above, and then to undertake another study further exploring infants' reactions to face-voice violations. It was necessary to determine whether infants in fact do respond differentially to violations of face-voice integrations, what kinds of violations produced differential responses, and whether an intersensory schema of a familiar object (the child's mother) existed and might differentially affect responsiveness to violations of face-voice schema.

Experiment I

Method

The basic setting and method of the two experiments was the same. Therefore, the following exposition applies to both, except as amended in the method section for Experiment II.

Subjects. The subjects were contacted by telephone after their names were found in the birth lists of the local newspaper. Appointments were made for a time when the child was awake and alert. The 35 subjects were Caucasian and came from varying social classes. Four female and 7 male 4-week-old infants (± 3 days), 5 female and 7 male infants 16 weeks old (± 7 days), and 6 female and 6 male infants 30 weeks old (± 14 days) participated. All infants were accompanied by their mothers.

Setting. The setting was designed to replicate that of Aronson and Rosenbloom (1971). The experiment was conducted in a 10' x 13' room which had two doors on one side and two one-way observation mirrors on the other. The room was divided by a piece of transparent Plexiglas, flanked by curtains, which created a sound barrier between the two sides of the room. An infant seat facing the Plexiglas and three, 8 inch deep speakers sat on the floor on one side of the room. The speakers were equidistant from the infant (39 1/2" from the back of the speaker), one directly in front of the infant and one on either side. Thus, voices could originate from any of the three speakers. The loudspeaker directly in front of the infant was designed to simulate normal voice-face pairings in which voice and face come from the same locus.

On the other side of the Plexiglas a chair was placed 50 1/2 inches in front of the infant seat. Here the mother sat and talked to her baby. Behind the chair a videotape camera was focused on the infant seat, and on the chair was a microphone.

Session. The mothers were told that this was a study of babies' ability to recognize their mothers' voices and voice-location discrepancy. They were assured that crying is a natural response and something we were interested in observing.

The mother put her baby into the infant seat. Then, she walked out, shutting the door on the baby's side of the room and entered and shut the door on the other side of the room visible to the infant through the Plexiglas screen. The mother then sat down, picked up the microphone, and began talking to her infant.

The mother was told to talk continuously, using her normal voice level and manner of vocal interaction with her baby. Due to efforts made to calm and/or wake the infants before the session began, no subjects had to be eliminated because of upset or sleepiness.

Stimuli. There were four 30-second stimuli presented in immediate succession over the 120-second session. From another room, the experimenter could select the loudspeaker through which the baby heard his mother's voice. The first and last stimuli were always mother's voice heard through the center speaker (C), the "normal" stimuli. The second and third stimuli consisted of the voice heard from right (R) and left (L) speakers sequentially, the "violation" stimuli or discrepancy condition. The order of right and left presentation was randomized over subjects. The mother was blind to which stimulus the baby was hearing, since she could not hear through the Plexiglas.

Measures. During the session, the babies' responses were filmed and viewed on a monitor in the experimenter's room. Any sound from the baby's side of the room was also recorded on the videotape and heard through the monitor.

An observer coded from the monitor during the session. The coding was blind, because changing locations of the voice stimuli were not detectable on the monitor. Eight infant behaviors were defined and coded:

Vocalize - S emits any neutral or pleasant sound from his vocal chords, including grunts and gurgles. Laughing, lip smacking, sighs, sucking, crying and burping noises are not included.

Smile/Laugh - S's mouth is broadened or turned up and/or he makes a laughing sound.

Frown - S's brow is furrowed, and/or his mouth is turned down, and/or his chin quivers.

Fret/Cry - S emits unhappy or unpleasant noises.

Look forward - S's eyes are turned toward the Plexiglas

Look right - S's eyes are turned toward the speaker on his right.

Look left - S's eyes are turned toward the speaker on his left.

Look down - S's eyes are turned toward the floor.

A measure of total looks was obtained by adding the four look measures. The coder recorded the number, not the length of the looking responses when they occurred. When the other responses occurred, they were coded only once within a stimulus condition. All coding was done by 30-second intervals.

The reliabilities were determined by another trained observer. The reliabilities ranged between .80 and .90.

Results

Since the number of subjects was small and the data were not normally distributed, nonparametric statistics were used. Two-tailed tests were used in all analyses. In general, the data were analyzed by a Randomization Test for Related Samples (Siegel, 1956) for all within-subject comparisons. A Wilcoxon Matched-Pairs Signed-Ranks Test was used to analyze combined age group data.

Mean data on each of the stimuli are presented by age group in Table 1.

Insert Table 1 about here

Fret/cry, frown, vocalize, and smile/laugh occurred infrequently. The frequency of these behaviors is too low for statistical significance to be obtained. Even so there were no patterns with regard to normal versus violation stimuli and the statistical analyses included only the looking measures plus vocalization.

The data on the two violations show a general increase in orienting to the correct direction of the voice with age, regardless of direction of voice. To analyze the interaction between looking direction (left or right) and voice position (left or right), we compared the number of looks right minus looks left for a right violation (R) to the number of looks right minus looks left for a left violation (L). The interaction was not statistically significant for the 1-month-old group, but reached significance ($p < .05$ and $.01$) in the 4- and 7-month-old groups respectively. There was also a tendency for the 1-month-old subjects to orient more to the right than left during the violation trials (adjusted for response during normal trials), but this difference was not significant.

In addition, a comparison of normal versus violation conditions indicated some differential responding for the other looking measures. For each looking measure, a within-subjects test of the direction of the difference to determine whether subjects looked around more, regardless of the direction of the violation, during violation than during normal stimuli revealed no significant differences for the 1-month group. However, there were significantly more left looks during the violation condition ($p < .02$) for the 4-month group, and more right looks, left looks, and total looks during the violation condition for the 7-month group ($p < .05$ or better). For the groups combined, there were significantly more left looks, right looks, and total looks during the violation than during the normal condition ($p < .01$, .05, and .02, respectively). Thus, in all cases, the significant differences indicated more looking during the violation than during the normal conditions.

The previous analysis seemed to indicate that one-month-old infants cannot discriminate violation from normal stimuli. Possibly, however, the within subject analysis disregarding direction would result in a different conclusion. We tabulated the total number of subjects differentiating between normal and violation stimuli. Differentiation was defined as the difference between the mean

Insert Table 2 about here

response to the normal stimulus trials and the mean response to the violation stimulus trials for each subject. Subjects were broken down into 3 groups: those who responded more to violation than normal stimuli; those who responded more to normal than violation stimuli, and those showing no difference (see Table 2). Thus, 8 one-month-old subjects showed stimulus differentiation on the "looks forward" measure. Of these 8, 6 responded more to the normal stimulus than the violation while 2 responded more to the violation stimuli than the normal. A similar analysis was performed for the 4- and 7-month-olds (see Table 2). While one-month-olds failed to show significant differentiation (8 out of 11, $p < .15$), the older ages did ($p < .05$ or better). With age a greater proportion of subjects differentially responded to normal versus violation ($p < .05$ with $\underline{df} = 2$, calculated by a Kruskal-

Wallis One-Way Analysis of Variance on the total proportion of subjects showing differentiation). In general, with age, a larger proportion of those subjects differentiating between normal and violation stimuli responded more to violation than to normal stimuli.

Discussion

The most important result of Experiment I was the failure to replicate Aronson and Rosenbloom's (1971) results. Those authors reported that 30-day-old infants were more upset during face-voice violations in which the voice was displaced from the face than during normal face-voice integration. However, the present study failed to find this effect for any of the age groups examined. Certainly, there are several reasons for the difference in results. First, more controls were instituted in the present experiment. Second, the measures used to determine the infant's disturbance were different. Because of Aronson and Rosenbloom's emphasis on it, tonguing was also noted in the present study, but there was no experimental evidence that tonguing correlated with any of the measures of distress or that it was more likely to occur during the violation stimuli. Third, there were, perhaps, critical procedural differences between the two studies, in addition to the use of monophonic versus stereophonic stimuli. For instance, Aronson and Rosenbloom eliminated subjects who showed distress at the beginning of the experiment, thus possibly selecting infants whose distress took longer to surface. (Randomizing the order of the stimuli would have controlled for this preselection problem.) Moreover, in Aronson and Rosenbloom's setup an observer was present in the room with the baby. It is possible that the stranger had a negative effect on the infant's affect.

The results of Experiment 1 suggest a growing tendency to orient one's eyes towards sounds. The data corroborate Piaget's (1952) observations regarding correct head orientation to sound. Turkewitz, Moreau, Birch, and Davis (1971) have found evidence of correct head orientation to sound as early as the first three days of life. Whether this response represents a developmental ability for localizing sound, or a maturational change in the physical ability for turning to one side or the other, is a question not answered in this paper. Increasing localizing ability, through learning or maturation or both, is a likely occurrence. On the other hand, several authors (Cernacek & Podivinsky, 1971; Gesell, 1938; Seth, 1973; Turkewitz, Gordon, & Birch, 1965) have, in fact, found evidence for various kinds of shifts in lateral preference and predominant side of orientation during the age range in question. If the degree and manifestation of these preferences is shifting within this age group, these lateral preferences might be influencing the child's ability to express localizing ability with appropriate head turns.

The evidence for discrimination between normal and violation stimuli is suggestive. The data seem to show that 1-month-olds look around slightly more during normal than during violation stimuli, while 4- and 7-month-olds do the opposite. The absolute differences between direction of looking during the normal and violation conditions indicate a growing amount of discrimination between the two with age. The result that, in general, there was more looking during the violation than normal stimuli led us to question whether increased eye turning is the result of localization efforts of the infants, or whether it is evidence of integration of face-voice schema. In order to investigate this question, it was necessary to violate the normal face-voice pairing in some other way. Therefore, a second study was undertaken.

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Experiment II

In order to improve the methodology of Aronson and Rosenbloom's (1971) study, to replicate the findings of Experiment I, and to explore further infants' ability to integrate faces and voices, the authors undertook a second study. Other kinds of face-voice violations were introduced to determine whether increased eye turning was in fact evidence for face-voice integration. We chose a method of changing the meaning of one of the components as it related to the face-voice pair, i.e., pairing the wrong voice with the wrong face. Experiment II was designed to investigate the relationship between a learned schema--a familiar face-voice pairing of the mother--and a more general ability to integrate the two stimulus modalities--the same pairing for a strange female. For these reasons, the reactions of infants to violations of face-voice pairings of both their mothers and female strangers were observed. In addition, we wished to know whether infants react to one part of the face-voice constellation or to the pair as a whole. Thus, the identity and presence of the face, the identity and presence of the voice, and the location of the voice were all varied. Finally, we changed the infant's orientation to see how his position affected eye turning.

Method

A six-factor within-subject design was used. There were two voice locations, two faces (mother and female stranger), two corresponding voices, eight stimulus orders, two age groups, and both sexes. The 18 different stimuli were presented in four series.

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Subjects. The subjects were 5 male and 2 female 4-week-olds (± 5 days), and 6 male and 4 female 16-week-olds (± 7 days). The infants were Caucasian, full-term, and came from varying social classes. The majority were from professional families and were firstborn.

Setting. The experiment was conducted in the same room as that used in Experiment I. A second room permitted a female adult, unseen by the baby, to talk to him through a microphone. At the same time, the adult could watch the baby on a television monitor. This adult could not hear what was being said by the experimenters in still another room. In this third room, which also included a TV monitor, Es selected the voice heard by the infant and the loudspeaker that transmitted that voice.

Sessions. Subjects were seen on two days which were usually consecutive. Two stimulus series were presented the first day and two the second day. Prior to each session the mother and stranger adjusted their voice levels so that on the baby's side of the room they seemed equally loud. Care was taken to ensure that the baby did not see the female stranger before the experiment. The same stranger was used in both sessions.

In the event that the subject became upset and fussy for more than two trials, a break was taken. If the break lasted over three minutes or if the baby had been crying too hard to register the stimuli, the entire series was repeated and only the second run-through scored. However, only two subjects needed a rerun.

As in Experiment I, both the mother and stranger talked continuously to the baby throughout all sessions. The adult in the baby's room began talking as soon as she entered her side of the room and picked up the microphone; her voice was heard through the central speaker. Shortly thereafter, the first trial began. At the end of each series, the voice of the person in the baby's room was switched back to the center. Thus, before and after each series, the infant experienced the adult's voice coming from the center. Both the mother and the stranger were blind to which voice the child was hearing.

Insert Table 3 about here

Stimuli. Eighteen stimuli were presented once each and divided into four stimulus series (see Table 3). Generally, each stimulus was presented for 30 seconds. However, it was necessary to be sure the baby was exposed to the integrated stimulus (both face and voice), i.e., that the baby was looking at the face when the voice changed. Therefore, the stimulus was changed either the first time after 30 seconds that the baby oriented to the Plexiglas, or after a total of 45 seconds, whichever came first. Only the first 30 seconds were coded. The child was seated facing the adult for all series except the side series during which he faced the speaker on his right. The orientation of the child was changed to control for head position preference and for interest in certain parts of the room.

The voices were transmitted through one of two speakers, the center and the one on the baby's right--although there were three speakers in the room. When an adult was present on the other side of the Plexiglas, the baby was always able to see her lips moving, regardless of whether and where he heard the voice.

The four series were (a) mother-visible, (b) stranger-visible, (c) no-one-visible (voice alone) and (d) S facing sideways (side). The mother-visible and stranger-visible series were the same except for the identity of the person in view. The mother-visible series consisted of all stimuli in which the mother was seated opposite the child and visible to the child; stranger-visible of all stimuli for which the stranger was opposite and visible. Mother-visible and stranger-visible were always presented on one day, no-one-visible and side conditions, the other. The order of days, of series within days, and of stimuli within series was randomized over subjects. The two series within each day were separated by a break during which the mother came over to the child's side of the room and interacted with him.

There were six conditions (see Table 3), which differed according to what voice(s) were heard by the child. The conditions were: normal, face-voice discrepant, face-only, one-voice, two-voices, and side.

Normal. This condition presented as normal a face-voice integration as possible; stimulus numbers 1 and 6 (see Table 3, last column to the right, for stimulus numbers).

Face-Voice-Discrepant. This condition consisted of six stimuli, two each of three kinds of violations.

(1) Right-side violation: The person and her voice, experienced in two different locations (stimulus numbers 3 and 8).

(2) Person violation: The person and another voice, coming from the center speaker (stimulus numbers 4 and 9).

(3) Person and right-side violation: The person and discrepant voice were experienced from two different locations (stimulus numbers 5 and 10).

Face-Only. This condition always occurred at the beginning or end of the mother-visible and stranger-visible series. The visible adult sat moving her lips silently (stimulus numbers 2 and 7). The beginning of this condition was signalled by a red light placed near to but out of view of the baby. Thus, the adult changed from speaking aloud to speaking silently. The end of the condition occurred when the red light went off and the adult changed back to speaking aloud. This was the only condition in which the adult knew what the child heard.[2]

One-Voice. These stimuli were presented with no one visible (stimulus numbers 11 and 14). At the beginning of this series, the mother hid behind the curtain on her side of the Plexiglas.

Two-Voices. This condition included stimulus numbers 15 and 16. The preceding three conditions were introduced to determine whether the infants were responding to the integrated face-voice stimulus, or only aspects of it.

Side. In this condition the child faced the right speaker instead of facing front (stimulus numbers 17 and 18).

Measures. Most of the measures were the same as for Experiment I. Look down and look left were not used. Two measures[3] were added and defined as follows:

Look Other - S's eyes are turned in any other direction besides forward or right. This measure included the look left and look down measures of Experiment I.

Quiet - S's bodily movements, vocalization, or fretting sounds markedly and suddenly decrease, especially in relation to attention to a new stimulus. Only one "quiet" response, therefore, was coded per stimulus.

Coding was done directly from the monitor. The location of the voice was unknown to the coder.

Reliabilities were computed on three randomly chosen subjects from each age group. After the experiment was over, an observer naive to the results of the experiment scored the data from the original videotapes. The reliabilities

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were .77 (looks forward), .98 (looks right), .70 (looks other), .82 (total looks), .98 (quiets), .76 (vocalizes), .98 (smiles/laughs), .92 (frowns), and .96 (frets/cries). The overall reliabilities were equally high: .82 and .87 for 1- and 4-month-old groups, respectively. The overall observer reliability for both age groups was .85.

Results

Since there were few subjects and the data were not normally distributed, two-tailed nonparametric statistics were used. The Randomization Test was used for all within-subject comparisons (which included most tests of differences), except those involving combined age groups or combined studies where the Wilcoxon Test was used. To compare age groups and the results of Experiments I and II, the Mann-Whitney U Test was used.

Replication of Experiment I

Experiment II failed to find significant differences in head orientation to the right during violations of the right side. However, the mean data are in that direction (see Table 4). Since there were no sample differences for the measure looks right for the normal mother stimuli and the mother right side

Insert Table 4 about here

violation stimuli, data from both experiments were combined. The combined data showed significantly more looks right during the right side violation than during the normal stimulus ($p < .02$ for the combined age groups and the 4-month-olds--this comparison was not significant for the 1-month-olds).[4]

Response to Violation Stimuli. As in Experiment I, comparisons were made between the response to normal and to violation stimuli. The stimuli were divided into four groups of violation stimuli. (A) All violations included all stimuli except the two normal stimuli and the side stimuli (17, 18) which were excluded from the calculations.[5] The next three groups comprised subsets of the stimuli in the All violations group. (B) Right-side violations consisted of those conditions when the voice came from the side speaker with the faces visible (stimulus numbers 3, 5, 8 and 10). (C) Face-voice violations encompassed stimuli in which the voice heard was not that of the person visible (stimulus numbers 4, 5, 9 and 10). (D) Face- and voice-only violations were conditions in which only the face or a voice(s) were present (stimulus numbers 2, 7, 11-16).

Means were computed for these groups and for the normal stimuli (see Table 5).

Insert Table 5 about here

As in Experiment I, there was little emotional behavior (vocalize, smile/laugh, frown, fret/cry, and quiet). Table 5 presents the means of all the measures. There was also no evidence of differential emotional responding during normal versus violation stimuli. Therefore, only the looking and vocalization measures were analyzed. The mean responses to the violation stimuli were compared with mean responses to the normal stimuli. Significant differences are indicated in Table 5.

For all categories of violations combined there was a significant difference from the normal condition for most of the looking measures (especially total looks) for both the four-month-old and the combined ages groups ($p < .05$ or better). The comparisons between the normal condition and the violation categories were not significant for any measures for the one-month-old group.

When the various categories of violations were compared there was no significant difference between them (Friedman Two-Way Analysis of Variance). Because of the manner of looking at the various violation categories, each contained stimuli in which a voice was presented to the side. Possibly, these stimuli were the ones causing the increased number of looks because the infants were searching for the location of the voice. To check on this possibility, we compared stimuli in which the voice identity differed from that of the face but both were in the same location (stimulus numbers 4 and 9) with stimuli in which the voice identity was the same as that of the face but there was a location discrepancy (stimulus numbers 3 and 9). If the increased looks were caused solely by the localization efforts, the two should be significantly different. In fact, there was no difference between them (n.s.) and they were both equally different from the normal condition ($p < .05$). Thus while violations from normal result in increased looking, at least for the four-month-olds, the nature of the violation did not seem to affect differentially the infant's behavior. This would indicate that face-voice discrepancy caused as much looking behavior as the face-voice displacement.

Response to Violations: Within-Subject Analysis. The previous analysis seemed to indicate that one-month-old infants could not discriminate violation from normal stimuli. However, as in Experiment I, it may be that a within-subject analysis disregarding direction would result in a different conclusion. In this analysis, we looked to see whether a subject himself showed a significant looking effect. This possibility was tested in a way similar to that used in Experiment I. The total number of subjects significantly differentiating between normal and violation stimuli was determined. Significance for each subject was computed by comparing the mean of the response to the normal stimulus with his response to each of the violation stimuli. The subjects who significantly differentiated between normal and violation stimuli were divided into three groups: those who looked around significantly more during violation stimuli, those who looked around significantly more during normal stimuli, and those showing no difference.

This analysis failed to indicate that one-month-olds were able to differentiate the normal from violation stimuli (only 28% showed significant differences in the looks). However, there was some difference in terms of how this discrimination was expressed at the two ages. There was a similar pattern found to that of Experiment I. Apparently most of the four-month-olds who responded significantly differently during normal versus violation stimuli looked more during violation stimuli ($p < .008$, Binomial Test for proportions), while, on the other hand, half the one-month-olds who differentiated between normal and violation stimuli looked more during normal stimuli ($p < .05$, Binomial Test for proportions).

Differential Response to Mother Versus Stranger. Tests of directional difference revealed no differential responding between mother and stranger stimuli for the normal and face-only condition and for violations involving the mother versus those involving the stranger.[6] However, there were some significant differences for the one-voice-only condition (more vocalizations, $p < .04$ and more looks other, $p < .03$, to the stranger's than to the mother's voice for the 4-month-old group).[7]

The Relationship between Mother/Stranger Differentiation and Differential Responding to Violation Versus Normal Stimuli. There remained the possibility that mother/stranger discrimination was related to the response to violations of normal face-voice integration. Thus, Spearman rank order correlations were computed between mother/stranger discrimination and response to violation stimuli. Differential responding to mother and stranger was represented by the absolute difference between the response to mother-normal and stranger-normal stimuli, while the response to the violation stimuli was represented by the absolute difference between the response to all the violation stimuli combined and the response to the normal. For neither the 1- nor the 4-month-olds were there strong correlations (either negative or positive) between mother-stranger discrimination under the normal conditions and the infants' ability to differentiate the normal stimuli from all the violation stimuli.

Voice-Only and Face-Only Comparisons. The next comparisons were analyzed to check whether the subjects were in fact responding to the integrated face-voice situation. They could have been responding only to the face (the visual dimension) or only to the voice (auditory dimension) rather than the face plus the voice. If so, one would expect a significant difference from one of the following comparisons: face-only versus face-voice stimuli, voice-only versus face-voice stimuli, or face-only versus voice-only stimuli. However, none of these were significant. It was still possible that infants' responses to the face-voice stimuli were determined by the fact that there were two parts to these stimuli rather than that the parts consisted of two separate modalities. If so, one would expect a significant difference from either of the following comparisons: intramodality stimuli having two parts (the two-voices stimuli) versus intermodality stimuli having two parts (the face-voice stimuli) or between stimuli having one part (face-only, voice-only stimuli) and those having two. The former comparison was not significant and neither was the latter (as demonstrated above). Thus, it seemed that the infants' reactions to face-voice stimuli represented neither a response to a single dimension alone nor one to two separate parts, but rather a response to an integrated intersensory stimulus.

Discussion

Recently, there have been reports of infants looking away from aversive stimuli (Bronson, 1972; Carpenter, 1973; Stechler, 1967). Although our subjects did not get upset during the violation conditions, our measure "looks other" might be another way of testing the aversiveness of the discrepant stimuli reported by Aronson and Rosenbloom (1971). However, this looking measure was not very different from the other looking measures. Certainly, the number of "looks other" provides no clear-cut evidence of such an aversive reaction. "Looking away" can also be interpreted in terms of stimulus monitoring, a cognitive rather than emotional response (Carpenter, 1973). Carpenter suggests that the looking away behavior of very young infants might be an attempt to alter the behavior of the stimulus. This suggestion may help to explain why the older infants in the present study spent more time looking away during violation than during normal conditions. In addition, Bronson (1972) found an increasing amount of looking away with age (3 through 9 months). However, since gaze aversion was rare when the babies were smiling, he concluded that it represented an emotional as well as a cognitive response. Perhaps gaze avoidance changes its meaning or the relative importance of its functions from cognitive monitoring to emotional expression (if these two functions can ever be separated) with age.

Thus, not only do infants at different ages express their discrimination ability differently, but the meaning of the discrimination may be different for the different ages. Still, the discrimination of such subtle differences between normal and violation stimuli is remarkable at such a young age.

The results support Aronson and Rosenbloom's (1971) results in showing early discrimination; however, young infants do <u>not</u> become upset when a voice is displaced from the person talking. There is evidence that indicates that even some one-month-old infants are able to discriminate between normal face-voice integration and violations of it if we look at absolute change rather than rely on a directional analysis. However, by four months most infants make this discrimination.

The present demonstration of four-month-olds' ability to discriminate between normal and discrepant face-voice integrations supports Piaget's (1952) proposal that intersensory integration begins at about 4 1/2 months of age (see also Decarie, 1965). Our own data suggest that this capacity may be present, at least for some infants during certain circumstances, as early as one month of age. The results from both Experiments I and II support the notion that at least by four months the infant has obtained a schema of a face-voice relationship. Thus the "look about" found in Experiments I and II is not only to localize the sound by orientating the receptor, but a search for the missing element of the integrated schema. This was demonstrated by the face-voice discrepancy condition of Experiment II. The findings of Piaget are based on the infant's active response to inanimate objects. The results of the present experiment suggest that when the response is directed to people and is reactive (i.e., doesn't involve an active motor response or intention), even younger infants can be shown to make this discrimination. Perhaps the one-month-olds were aided in the discrimination by the diverse and numerous cues emitted by humans and by the affective bond infants have with people. Bell (1970) showed that person permanence generally develops earlier than object permanence. Using reactive responses, Bower and Paterson (1973) postulate the existence of perceptual precursors of object permanence; since we measured reactive responses too, perhaps the one-month-olds were demonstrating these perceptual precursors.

Two previous studies did not find differential responsiveness to face-voice discrepancy in early infancy. S. Cohen (1973) found no differential response to discrepancy at 5 months, and differentiation only for some infants at 8 months. Carpenter (1973) also did not find significant differential responsiveness between ages 2 to 7 weeks to a voice-face discrepancy (although results are in that direction). The differential results can probably be explained on procedural grounds. In the present experiment, the adults were allowed free speech in response to the infant's actions (contingent verbal behavior), whereas in Carpenter's (1973) experiment the adult recited a rote passage (noncontingent verbal behavior). Some research (Bronson, 1972) indicates increased wariness by infants who fail to elicit expected reactions in a social situation. S. Cohen (1973) used only first fixation measures which were probably not sensitive enough.

Several studies do report that during speech there is a suppression effect of either motoric activity (Tulkin, 1971; Turnure, 1971) or of vocalization on the part of the infant (Barrett-Goldfarb & Whitehurst, 1973; Jones & Moss, 1971; Lewis & Freedle, 1973; Webster, 1969) for the age range three to twelve months. This effect is ascribed to the fact that infants are differentially listening to the speech. Tulkin (1971) and Barrett-Goldfarb and Whitehurst (1973) found significantly more suppressed vocalization or motor activity to the preferred person's voice; the suppression was viewed by these authors as a measure of listening preference. The present study supports this finding at the even younger age of four months. In addition, there was more "looking other" during the stranger's voice in contrast to the mother's voice for the four-month-olds. The latter finding may also indicate greater motor activity and less attention during the time the less preferred person was talking. From the animal literature, Gottlieb (1973) who studied normal and discrepant face-voice integration and its effect on the following behavior of ducklings found the identity of the adult duck's voice (mother of own species versus another species) to be more important than her visual attributes. Nevertheless, the largest amount of following occurred when both the mother duck's face and voice were paired. In the present case as well, the identity of the voice (mother versus stranger) seemed to have more discriminative effect on the infant's responses than did her visual attributes.

The side presentation condition provided an opportunity to examine the relative interest in the face versus the voice as indexed by head turning and to disentangle interest in the face from head turning ability. The infants oriented as much towards the face regardless of the position of the infant seat. However, four-month-olds, especially, could differentially turn towards the direction of the sound, showing that they were not visually captured, although they evidently chose to look in the direction of a face when one was present. In addition, differential response occurred to neither the voice alone nor the face alone. This result contrasts with Carpenter's (1973) finding (using duration measures) of the salience of the face alone versus voice alone, probably because the infants in her study were so close to the stimuli (only 10" away).

Although there was no discrimination between normal mother and stranger stimuli, the infants did seem to recognize whose voice went with whom. Evidently they were able to discriminate a violation of the normal pairing of voice with person from the normal pairing (see Table 5). Tulkin (1972) reports that some ten-month-old subjects looked in the direction of the correct person (mother versus stranger) when that person's voice was heard over a loudspeaker (locus violation). In the past (Lewis, 1969; McCall & Kagan, 1967) the violation of intrasensory schemas has provided additional information about the infant's response to normal schemas. It now seems that infants' responses to violations of intersensory schemas can also reveal capacities not otherwise apparent.

In general, one of the most important aspects of the study is the evidence that infants respond to an integrated, intersensory face and voice stimulus and not to one aspect of the situation (either the face or the voice, or the fact that two separate stimuli are presented). Two results especially support this conclusion. First, there was no significant difference between response to displaced voices versus to other violations, a difference one would have expected if the increased number of looks during violations as in Experiment I represented a mere search for the sound's location. The lack of difference indicates that the increased number of looks from the normal condition is a result of violating an intersensory face-voice schema. Second, the discrimination was not the mere recognition of a difference between any two stimuli. Donnee's (1973) results on infants ages 4 through 11 weeks also tend (although not significantly) to argue for integration between faces and voices, since there was differential responding to various auditory stimuli depending on the visual stimulus present.

This finding is very important for our conception of the infant's perception of his world and the way in which this perception develops. Perception which integrates many parts of the environment is apparently possible in earliest infancy and may be normal at this stage of development, rather than exceptional. Thus, infant perception includes a capacity for holistic perception where the perception of the whole transcends the perception of the parts. This does not mean, however, that the young infant's perception is a global "buzzing confusion," but rather that there is some meaningful organization of more than one aspect of the environment. Indeed, human perception as a totality may be fundamentally integrative, or holistic, rather than mechanistic, piece-meal, or atomistic. Apparently even ducklings can perform such integrations (Gottlieb, 1973). Until recently, little research had been done on intersensory integration, but fortunately more researchers have started work on this important problem (Carpenter, 1973; S. Cohen, 1973; Dale, 1973; Dornee, 1973).

Much of the literature on incongruity as well as infant development assumes that concepts develop as generalizations from particular schemas (for instance, a schema of something familiar) rather than proceeding from more general and integrative schema (for instance, schemas of laws about the environment in general) to more specific ones. Thus, one might expect infants to react more to mother-violations (an unfamiliar aspect of a familiar person) than to stranger-violations (an unfamiliar aspect of an unfamiliar person), at least if the infants have a specific mother "schema." No difference between mother and stranger as subjects of violation should be expected if the response to violation involves a more general schema (for instance, the concept "person") rather than a reaction to the discrepancy from a particular schema (mother). Regardless of the direction of development, the general concept ("person") may be learned from experience with a specific situation (the caretaker). Our data do not answer this satisfactorily. It may very well be that both types of changes are simultaneously taking place during development (Werner, 1948) and that neither is primary. Perhaps instead of asking the question of which precedes the other, we should ask how these processes interact and under what circumstances each becomes operative.

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Footnotes

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[2]This procedure, rather than switching of the speakers, was used in order to insure that no sound would pass across the sections of the room to the infant.

[3]"Looks other" instead of look down and look left was added as a more systematic measure of whether the infant looked towards neither the places where the voice came from nor where the voice was located. "Quiets" was also added in order to measure, in part, attention to the auditory portion of the stimuli.

[4]See Tversky and Kahneman (1971) for a discussion of why combining two sets of data is appropriate.

[5]The reason for this comparison was to determine whether the response to the face _versus_ to the voice was affected by the infants' placement. The infant's position in the room did not seem to have an effect on head orientations to the voice. Since the comparison of response to face versus voice was not the purpose of the previous comparisons, the issue of the effect of orientation in the room was excluded from further consideration and stimuli 17 and 18 were omitted from the analyses in this paper.

[6]In the latter comparison, voice-only stimuli presented to the side were excluded because in this case . comparison between attention to voice and to face was being made and there were no occasions during which the face was presented to the side.

[7]Mother violations consisted of stimuli 2-5, 11 and 12 corrected for response to the normal stimulus; stranger violations were similarly defined.

Table 1

Mean Number of Behaviors as a Function of Direction of Voice

Conditions	Normal	Voice Displaced to Right Side	Voice Displaced to Left Side	Normal
Measures				
1 Month (N=11)				
Looks Right	1.0	1.4	1.8	1.0
Looks Forward	1.2	1.4	1.1	1.4
Looks Left	0.7	0.5	0.5	0.7
Looks Down	0.3	0.3	0.3	0.5
Total Looks	3.1	3.6	3.6	3.7
Vocalizations	0.3	0.1	0.1	0.0
Smiles/Laughs	0.0	0.2	0.1	0.0
Frowns	0.3	0.3	0.3	0.5
Frets/Cries	0.1	0.3	0.1	0.1
4 Months (N=12)				
Looks Right	0.3	1.1	0.3	0.6
Looks Forward	2.9	2.4	2.8	2.6
Looks Left	0.2	0.4	1.2	0.0
Looks Down	1.4	1.1	0.8	1.2
Total Looks	4.8	5.0	5.1	4.4
Vocalizations	0.2	0.2	0.4	0.2
Smiles/Laughs	1.0	0.3	0.5	0.3
Frowns	0.3	0.1	0.2	0.3
Frets/Cries	0.0	0.2	0.2	0.1
7 Months (N=12)				
Looks Right	0.1	1.0	0.2	0.3
Looks Forward	2.3	2.4	2.6	2.2
Looks Left	0.2	0.7	1.[illegible]	0.2
Looks Down	1.3	1.5	1.2	1.3
Total Looks	4.0	5.6	5.2	4.0
Vocalizations	0.0	0.6	0.2	0.1
Smiles/Laughs	0.7	0.3	0.6	0.4
Frowns	0.0	0.1	0.2	0.0
Frets/Cries	0.0	0.1	0.1	0.3
Combined Ages (N=35)				
Looks Right	0.4	1.1	0.7	0.6
Looks Forward	2.2	2.1	2.2	2.1
Looks Left	0.4	0.5	1.0	0.3
Looks Down	1.0	1.0	0.8	1.0
Total Looks	4.0	4.8	4.7	4.0
Vocalizations	0.2	0.3	0.2	0.1
Smiles/Laughs	0.5	0.3	0.4	0.2
Frowns	0.2	0.2	0.2	0.2
Frets/Cries	0.0	0.1	0.2	0.2

Table 2

Number of Subjects Looking Differentially between

Violation and Normal Conditions

Measures	Looks Forward	Looks Right	Looks Left	Looks Down	Total Looks	Vocalizations
Effects						
1 Month (N=11)						
Looks more during violation stimuli	2 (18%)[a]	4 (36%)	1 (9%)	1 (9%)	4 (36%)	1 (9%)
Looks more during normal stimuli	6 (54%)	0 (0%)	3 (27%)	3 (27%)	2 (18%)	2 (18%)
Total showing differentiation	8 (73%)	4 (36%)	4 (36%)	4 (36%)	6 (54%)	3 (27%)
4 Months (N=12)						
Looks more during violation stimuli	3 (25%)	6 (50%)	7 (58%)	2 (17%)	8 (67%)	4 (33%)
Looks more during normal stimuli	7 (58%)	2 (17%)	0 (0%)	5 (42%)	2 (17%)	2 (17%)
Total showing differentiation	10 (83%)	8 (67%)	7 (58%)	7 (58%)	10 (83%)	6 (50%)
7 Months (N=12)						
Looks more during violation stimuli	6 (50%)	7 (58%)	9 (75%)	6 (50%)	8 (67%)	5 (42%)
Looks more during normal stimuli	3 (25%)	1 (8%)	1 (8%)	5 (42%)	2 (17%)	0 (0%)
Total showing differentiation	9 (75%)	8 (67%)	10 (83%)	11 (92%)	10 (83%)	5 (42%)
Combined (N=35)						
Looks more during violation stimuli	11 (31%)	17 (48%)	17 (48%)	9 (26%)	20 (57%)	10 (28%)
Looks more during normal stimuli	16 (46%)	3 (8%)	4 (11%)	13 (37%)	6 (17%)	4 (11%)
Total showing differentiation	27 (77%)	20 (57%)	21 (60%)	22 (62%)	26 (74%)	14 (40%)

[a]Percentages refer to the percentage of subjects at that age making this discrimination.

Table 3

Stimulus Descriptions for Experiment II

Series	Subject's Direction	Condition	Stimulus Description	
Mother-Visible	Facing Plexi-glas	Normal	Mother visible, mother's voice center	(1)
		Face-Only	Mother visible, no voices	(2)
		Face-Voice-Discrepant		
		1) Location	Mother visible, mother's voice right	(3)
		2) Person	Mother visible, stranger's voice center	(4)
		3) Both Location & Person	Mother visible, stranger's voice right	(5)
Stranger-Visible	Facing Plexi-glas	Normal	Stranger visible, stranger's voice center	(6)
		Face-Only	Stranger visible, no voices	(7)
		Face-Voice-Discrepant		
		1) Location	Stranger visible, stranger's voice right	(8)
		2) Person	Stranger visible, mother's voice center	(9)
		3) Both Location & Person	Stranger visible, mother's voice right	(10)
No-One-Visible	Facing Plexi-glas	One-Voice	No one visible, mother's voice center	(11)
		One-Voice	No one visible, mother's voice right	(12)
		One-Voice	No one visible, stranger's voice center	(13)
		One-Voice	No one visible, stranger's voice right	(14)
		Two-Voices	No one visible, mother's voice center, stranger's voice right	(15)
		Two-Voices	No one visible, stranger's voice center, mother's voice right	(16)
Side	Facing right	Normal	Mother visible, mother's voice center	(17)
		Face-Voice-Discrepant		
		1) Location	Mother visible, mother's voice right	(18)

Note.--The numbers in double parentheses represent the stimulus numbers.

Table 4

Mean Number of Behaviors as a Function of Voice Direction

Conditions	Normal			Violations of Right Side		
	Mother	Stranger	Total	Mother	Stranger	Total
<u>Measures</u>						
1 Month (N=7)						
Looks Right	1.1	.7	.9	1.1	.7	.9
Looks Forward	1.3	1.1	1.2	1.1	1.4	1.2
Looks Other	.4	1.0	.7	.7	1.6	1.1
Total Looks	2.8	2.8	2.8	2.9	3.7	3.3
Vocalizations	.1	.3	.2	.1	.4	.3
Smiles/Laughs	0	0	0	0	0	0
Frowns	0	.1	.1	0	.3	.1
Frets/Cries	.3	.1	.2	.3	0	.1
Quiets	0	0	0	0	0	0
4 Months (N=10)						
Looks Right	.1	.2	.2	.6	.4	.5
Looks Forward	1.6	2.0	1.8	1.8	2.6	2.2
Looks Other	1.2	1.1	1.2	1.1	1.8	1.4
Total Looks	2.9	3.3	3.1	3.5	4.8	4.2
Vocalizations	.1	.4	.2	.2	.4	.3
Smiles/Laughs	.1	.1	.1	.1	.2	.15
Frowns	.3	.1	.2	.2	.1	.15
Frets/Cries	.3	.3	.3	.2	.2	.2
Quiets	0	0	0	0	.1	.05
Combined Ages (N=17)						
Looks Right	.5	.4	.5	.8	.5	.7
Looks Forward	1.5	1.6	1.6	1.5	2.1	1.8
Looks Other	.9	1.1	1.0	.9	1.7	1.3
Total Looks	2.9	3.1	3.0	3.2	4.4	3.8
Vocalizations	.1	.4	.2	.2	.4	.3
Smiles/Laughs	.1	.1	.1	.1	.1	.1
Frowns	.2	.1	.1	.1	.2	.1
Frets/Cries	.3	.2	.3	.2	.1	.2
Quiets	0	0	0	0	.1	0

Table 5

Means and Significance[a] Levels of the Violations

Conditions	Normal	All Violations	Right Side[b]	Face-Voice	Face & Voice Only[c]
<u>Measures</u>					
1 Month (N=7)					
Looks Right	.9	.7	.9	.9	.6
Looks Forward	1.2	1.3	1.3	1.5	1.1
Looks Other	.7	1.3	1.0	1.0	1.2
Total Looks	2.9	3.1	3.2	3.4	2.8
Vocalizations	.2	.2	.3	.2	.1
Smiles/Laughs	0	0	0	0	.1
Frowns	.1	.1	.1	.1	.1
Frets/Cries	.2	.2	.1	.1	.2
Quiets	0	0	0	0	0
4 Months (N=10)					
Looks Right	.2	.8**	.9**	1.0***	.7
Looks Forward	1.8	2.4**	2.6**	2.6***	2.4
Looks Other	1.2	2.0	1.5	1.4	1.9*
Total Looks	3.1	4.8***	5.0***	5.0***	5.0***
Vocalizations	.2	.2	.3	.3	.2
Smiles/Laughs	.1	0	.1	.1	0
Frowns	.2	.1	.2	.2	.1
Frets/Cries	.3	.1	.2	.2	0
Quiets	0	0	.1	0	0
Combined Ages (N=17)					
Looks Right	.5	.8	.9*	.9*	.7
Looks Forward	1.6	2.0*	2.0***	2.2***	1.9
Looks Other	1.0	1.7**	1.3	1.2**	1.6***
Total Looks	3.0	4.1***	4.2***	4.3***	4.1*
Vocalizations	.2	.2	.3	.3	.2
Smiles/Laughs	.1	0	.1	0	0
Frowns	.1	.1	.2	.1	.1
Frets/Cries	.3	.1	.2	.2	.1
Quiets	0	0	0	0	0

*p .05

**p .02

***p .01

[a] Responses to the violations were tested against those to the normal stimuli.
[b] Spatial displacement same as Experiment I.
[c] Right side violations comprised stimulus numbers 3, 5, 8 and 10; Face-Voice violation--numbers 4, 5, 9, 10; Face and Voice only--numbers 2,7,11-16 (see Table 3).

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